

## ON THE USE OF THE ABSOLUTE GALVANOMETER, WITH DESCRIPTION OF HIRSCHMANN'S NEW INSTRUMENT.\*

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*(With one wood-cut.)*

THE introduction of a unit of current strength into medical electricity has been generally approved of in England, Germany, and France. In Germany, Bernhard<sup>1</sup> Eulenburg,<sup>2</sup> and Erb<sup>3</sup> have, for the past few years, insisted on the necessity of establishing a standard of electrical measurement, while the progress which has been made in this direction in England and France is due chiefly to the warm advocacy of De Watteville in London, and the persistent efforts of Gaiffe in Paris. Strangely enough the question has not received the consideration it deserves at the hands of American physicians.

That much good work has been done in electro-therapeutics by neurologists of this country no one will dispute. The more reason, therefore, why they should adopt a method which will enable them to apply electricity, or at least the galvanic current, with scientific accuracy.

The disadvantages of the old, or rather, the present method of gauging the quantity of electric force employed in any one case must be apparent to all who are in the habit of using electricity either for therapeutic or diagnostic

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<sup>1</sup> Rosenthal u. Bernhardt "Electrizitätslehre," &c., Berlin, 1884.

<sup>2</sup> *Deutsche Med. Wochenschrift*, Feb. 21, 1884.

<sup>3</sup> Erb "Elektrotherapie," Leipzig, 1882.

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purposes. To say that we have used the electromotive force of a certain number of cells gives but an imperfect idea of the actual current yielded ; for the capacity of the cells, not only of a different, but of one and the same battery, varies greatly, and that too from day to day. To add the number of degrees to which an ordinary galvanometer needle was deflected, and the units of resistance which were introduced, does not improve matters much ; for the deflection of the ordinary magnetic needle does not remain proportional to the strength of current employed, and with two variable factors in the calculation, a third, more positive one, loses much of its value. The physician who observes his galvanometer, rheostat, and battery from day to day may form a relative estimate of the amount of electricity used in one instance or the other, but he cannot represent the strength of this current to himself and others in terms of an intelligible unit.

Hitherto we have been groping in the dark ; we have employed a powerful therapeutic agent without troubling ourselves much about its dosage. Those who do not insist on absolute accuracy at all times might argue that much good and little harm were done under the old régime ; that the subjective sensations of the patient are a sufficient guide for the physician ; that the patient will be prompt enough in letting the physician know when he is administering too much. Granting the reliability of the patient, I would reply that from the therapeutic point of view, a very weak current may be as injurious as a very strong one. But it is not so much a question of doing right or wrong ; it is a question of doing work accurately or shiftlessly ; of knowing exactly what one is about, or of leaving every thing to chance. Few seem to realize that we should apply electricity with the same care with which we administer any potent therapeutical agent.

Whether such great accuracy and care in treatment be necessary or not, may be left to the judgment of the individual. For the purposes of electrical diagnosis, however, there is little doubt of the advantages which an instrument indicating the strength of the galvanic current

passing through the body in terms of a known unit would possess over our present imperfect means of registering this amount. With the use of an absolute galvanometer, we shall soon gain some definite conception of the current strength required to produce, say, kathodic closure contraction of any nerve or muscle, and to compare with this figure the current strength required to excite the same nerve or muscle under pathological conditions. In passing I will add that tables, stating the normal limits between which the various contractions take place, have been formulated by Eulenburg,<sup>1</sup> Weiss,<sup>2</sup> and others. Having once accustomed ourselves to these units of measurement, we shall ever afterwards speak and write of electrical quantities in terms intelligible to all.

The question is: Which unit to employ? Fortunately for us, there is little room for discussion on this head. Not being the leaders in this movement, we can do no better than to follow suit. Some years ago De Watteville proposed the milliampère as a standard of measurement. The same unit, though at first employed under another name, the milliweber, has been adopted by German investigators, and the instrument which I shall describe later on is graduated in accordance with this unit.

It is quite probable that for the nonce the French will come to terms with the English and German neurologists, and will adopt the same standard. What we should do seems evident enough; but on this subject it is your privilege to legislate. Here tradition is not the stumbling-block it has proved to be in the adoption of an international standard of weights and measures. We have simply to

<sup>1</sup> *Loc cit.*

Here are a few extracts from Eulenburg's tables:

Current strength required to produce first KCC:

Facial nerve	(Trunk)	in 24 cases	0,6—2,0 M.-A.
" "	(Branches)	" 9 "	0,5—1,5
Median "	(Upper Arm)	" 4 "	0,7—1,2
Ulnar "	(Elbow)	" 10 "	0,4—0,8

Similar tables should be constructed giving the limits between which ACC, AOC, and KOC, may occur in the normal. Much loose talk regarding reaction of degeneration, etc., would cease if we required the exact strength of current to be registered at which the various forms of contraction were observed.

<sup>2</sup> *Centralblatt für die gesammte Therapie*, Jan., 1883, p. 11.

consider whether the unit of measurement adopted in other countries is the most practicable ; if so, we are bound to make this unit our own. It has been abundantly shown that a milliampère and its multiples correspond quite accurately to the quantity of electricity generally employed for purposes of treatment or diagnosis. With the average resistance of the human body the current of 10, 20, 30, or Daniell would aggregate to 5, 10, or 20 milliampères.

I have said that the milliampères was proposed and approved of as a unit of measurement some years ago ; but until quite recently we possessed no entirely satisfactory absolute galvanometers. The difficulties encountered in the construction of these instruments seemed almost insuperable.

In 1873, Gaiffe constructed a horizontal absolute galvanometer, which he graduated according to ten-thousandths of a unit of intensity ; later on he was persuaded to exchange this clumsy and rather unintelligible subdivision for a division into milliampères. To this instrument there was the one serious objection which must be urged against all horizontal galvanometers. The deflection of a horizontal needle varies with the difference of magnetic force at various points of the earth's surface. A current causing a deflection of 10 degrees, observed in Paris, would not be equivalent to the current producing a similar deflection in New York or London. Gaiffe's galvanometer, moreover, was found to be unreliable and not sensitive enough ; De Watteville<sup>1</sup> alone, who makes no mention of any other absolute galvanometers, is enthusiastic in praise of this instrument. Similar galvanometers were constructed in the latter half of the last decade and the beginning of this by Böttcher and Stöhrer, and by Edelmann of Munich.

In Edelmann's galvanometer, which was graduated according to milliampères, a bell-shaped magnet was employed and suspended by a short silk thread. This mechanism reduced the number of oscillations, but at the same time rendered the instrument almost too delicate for use. A small pocket galvanometer which Edelmann invented would be

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<sup>1</sup> De Watteville : " *Med. Electricity*," 2d edit., 1884.

more practicable if the needle were not open to the objections urged above against all horizontal galvanometers. Böttcher and Stöhrer, as well as Hirschmann, profiting by these imperfect efforts, constructed *vertical* galvanometers, which they supposed would be entirely independent of terrestrial magnetism. Much to their surprise it was proved by Müller,<sup>1</sup> of Wiesbaden, that the ordinary vertically suspended needle was subject to the same disturbing influence, though not to as marked a degree as the horizontal galvanometers. To counteract the influence of the magnetic force of the earth Hirschmann finally set out to construct a *vertical absolute* galvanometer, and of using not a single needle but a pair of astatic needles.

In the light of past experiences and our present needs, we may insist that an entirely satisfactory galvanometer must meet the following requirements: The instrument must indicate the exact strength of current passing through the body; and any deflection of the needle must be equivalent to the same quantity of electricity the world over. We have seen that this can be best effected by the use of astatic needles. The instrument must be sensitive enough to indicate the passing of a current through any part of the body before the patient perceives the current. The needle must come to rest quickly after the current is broken. The instrument must be substantial in structure; and, lastly, must permit of an easy adjustment to all batteries, stationary and portable. All these conditions are fulfilled, with perhaps one or two exceptions, by the instrument before you.

Now as to the notable features of this absolute galvanometer.

The annexed figure represents as much of Hirschmann's galvanometer as is visible without removing the wooden box ( $7\frac{1}{2}$  in. high) in which the instrument is enclosed. Its distinguishing feature—the use of a pair of vertically adjusted astatic needles—was referred to above.

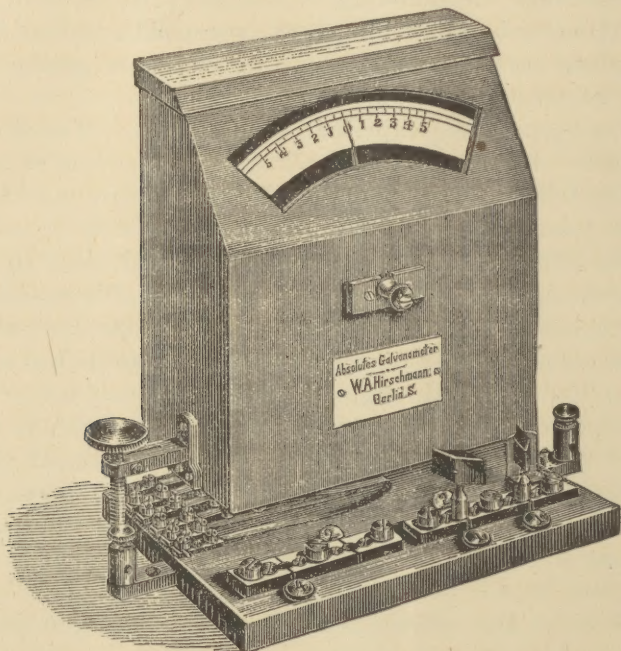
The two needles have a common axis. The posterior needle swings between two coils of insulated wire; the anterior needle swings in front of these coils, and carries the indi-

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<sup>1</sup> Müller: "Zur Einleitung in die Elektrotherapie." Wiesbaden, 1885.

cator at its upper end. The indicator and scale are visible through the aperture in the upper part of the box. The scale, which is drawn (by hand) on an arc, is subdivided into ten equal parts on each side of the median line. The whole scale indicates 5 milliamperes; each line denoting  $\frac{1}{2}$  M.-A. The proportions of this scale are such that a variation of  $\frac{1}{8}$  M.-A. could easily be noted.

This is an important point to remember when comparing this instrument with others. We must be able not only to



detect slight variations in the deflection of the needle, but also to read the scale at some distance from the table on which it stands.

In order to retain a scale of such liberal dimensions, without increasing the size of the instrument, Hirschmann introduced "shunts," which are situated in the corners of the box, at a safe distance from the main coils.

If the plugs be inserted at 1, 1, the whole of the current passes through the galvanometer proper, and the strength

of current is exactly that indicated on the scale. If the plugs be inserted at 2, 2, the current is divided, one half passing through the main coils and the other half through a shunt, offering precisely the same resistance to the current that the main coil does. The strength of the current, therefore, is double that indicated on the scale. If one plug be removed and the other inserted at 4, but one fourth of the whole current need pass through the galvanometer proper, since a shunt of one third the resistance of the main coil has been introduced into the circuit. The actual strength of current will be four times that denoted on the scale. In this way we are enabled to measure currents varying in intensity from one half to twenty milliampères.<sup>1</sup>

As is seen in the figure, the instrument is firmly fixed on the right side, while it rests upon springs and a movable screw on the left. By turning this screw up or down the instrument is made to stand level, and the needle is kept at zero. On either side of the instrument are the binding screws, by means of which the instrument is connected with the battery. The resistance of the galvanometer is equivalent to 500 Siemens' unities, or 471 Ohms. This resistance does not vary with the introduction of the shunts into the circuit, for if the connections 2, 2, or 4 be made, resistances of 250 and 125 S. unities are respectively added to the resistance of the main coil.

After a year's experience with this instrument, I am prepared to say that it has done me excellent service.

I know of but two possible objections to this galvanometer. The one is that it does not bear transportation well, and the other that the return of the needle to the zero point is (very) slightly impeded by the action of friction. Others who have used the instrument have been disturbed by the oscillations of the needle. These are excessive only in case a current of great strength is suddenly broken. The number of oscillations is held in check by a metal damper surrounding the posterior needle.

I have given a detailed description of this absolute galvanometer in order to do justice to the ingenuity of its in-

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<sup>1</sup> With ordinary electrodes, currents of greater strength are seldom employed.

ventor, and to acquaint the reader with the happy manner in which the problems of galvanometer construction have been solved. I cannot, and do not, expect neurologists of this country to use Hirschmann's instrument to the exclusion of all others; but with the peculiar merits of this instrument before them, they will be able to gauge the merits of any other instrument which may be brought to their notice. Let our electricians and instrument-makers try their own skill in this work, but let them profit also by the experience of their European colleagues.

NOTE.—Since writing the above, Mr. John A. Barrett, of this city, has shown me an absolute galvanometer which he constructed at the request of a well-known physician. When a few modifications shall have been made, the instrument will probably meet all the demands detailed above.